Stackables: Faceted Browsing with Stacked Tangibles

Petra Isenberg, Stefanie Klum, Ricardo Langner, Jean-Daniel Fekete, Raimund Dachselt

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Petra Isenberg
Team AVIZ
INRIA
petra.isenberg@inria.fr

Jean-Daniel Fekete
Team AVIZ
INRIA
jean-daniel.fekete@inria.fr

Stefanie Klum
UISE Group
University of Magdeburg
stefanie.klum@steelis.net

Raimund Dachselt
UISE Group
University of Magdeburg
dachselt@acm.org

Ricardo Langner
UISE Group
University of Magdeburg
rlangner@ovgu.de

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Abstract
We demonstrate *Stackables*, tangible widgets designed for individual *and* collaborative faceted browsing. In contrast, current interfaces for browsing and search in large data spaces largely focus on supporting either individual *or* collaborative activities. Each stackable facet token represents search parameters that can be shared amongst collaborators, modified, and stored. We show how individuals or multiple people can interact with Stackables and combine them to formulate queries on realistic datasets. We have successfully used and evaluated Stackables in a user study with a dataset of over 1500 books and 12 facets with ranges of thousands of facet values.

Keywords
Tangible UIs; faceted browsing & search; collaboration

ACM Classification Keywords
H.5.2 [**User Interfaces**]: Input devices and strategies.

Introduction
Imagine a medium-sized business has to decide on the purchase of computer equipment for its employees. The decision on what to purchase can have profound impact on employee productivity and business profitability and choices on options and specifications are therefore not easy to make. Typically, decision makers from several departments with varying priorities and skills are involved

Figure 1: Three Stackables combined in a query stack.

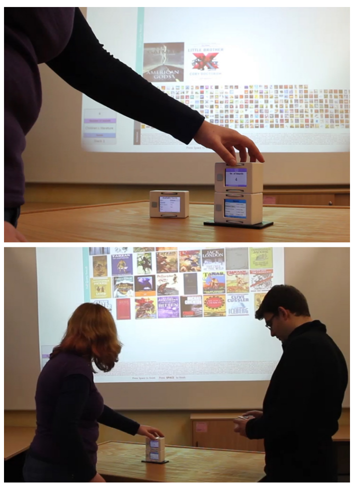

Figure 2: Stackables are small tangibles for faceted browsing that can be used alone or together with others.

in the selection process. Faceted browsing can help decision makers: they can consider data from different conceptual dimensions and incrementally refine a dataset by restricting facet values such as price, technical attributes, or ratings (e. g., [4, 7]).

The scenario above poses a number of challenges to regular faceted information seeking interfaces: (a) The decision makers will likely begin with a private search and later have to share and discuss their results as well as facet values which led to them. (b) During a decision meeting, the shared use of an information seeking interface can help to advance the discussion and clarify options. Such an interface needs to be easily set up and to allow participants to fluidly share, transfer, and manipulate facet values while working in a closely or loosely coupled fashion [5].

Stackables were designed to address these challenges: to bridge the gap between individual and collaborative work phases, be useful in meetings, and for sharing results from search activities in large data sets. Each Stackable tangible physically represents search parameters that can be shared amongst collaborators, modified during an information seeking process, and stored and transferred.

Stackables: Design

Several benefits of tangible interfaces made them a promising option to tackle the mentioned challenges: Tangibles allow parallel interactions in a co-located setting (cf. [6]), tangible facet representations visualize queries in a physical form (cf. [8]), and allow direct input for all participants. Finally, tangible query representations are a form of physical manifestation of the result of an information seeking *process* that can be stored and re-accessed for further work in other settings.

We designed our stackable tangibles to support:

R1 realistic datasets (large number of facets & values),
R2 faceted browsing principles, simple boolean queries,
R3 separation of search input and result output (no tabletop needed, just regular meeting spaces),
R4 use in both individual and collaborative work phases.

Stackables consist of two main components: facet tokens and ground plates (see Fig. 1).

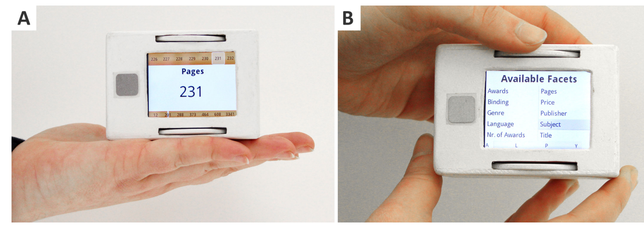

Figure 3: Stackables size related to a female hand (A) and when held between two hands (B, available facets in a book dataset are shown).

Tokens Facet tokens as the main building blocks are stacked (cf. [3]) to form queries. A token can represent any numeric or categorical facet in our dataset and can be assigned and re-assigned on the fly. Thus, each Stackable is generic and contains information about all facets and their values. All tokens share a similar abstract box shape that can be easily stacked. The token's box is held in a neutral white to further emphasize its versatility in facet choice (R1). Facet type is not encoded permanently on the box to allow for reuse. Instead, a color-display on the front shows facet data. Two turnable wheels at the top and bottom (accessible from the front and the back) allow for selection of facets and facet values. The display and wheels are positioned off-center so that the up-direction of a token is readily visible. This also gives room for a button-like area on the left, e.g. used for selection (see Fig. 3).

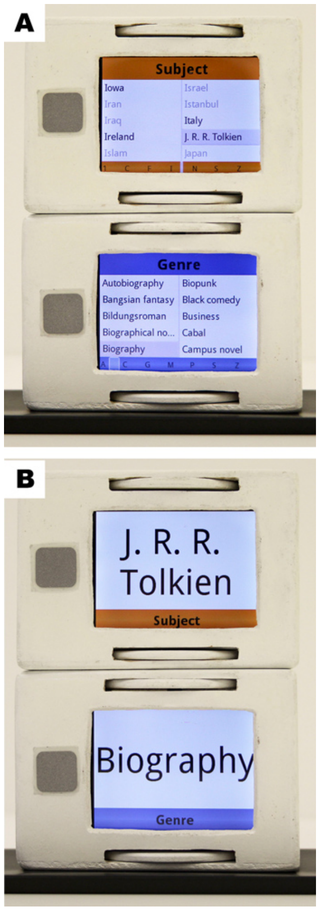

Figure 4: Two facet tokens in a stack. A: The top showing available values in black and unavailable values in grey. B: The selected facet values shown after a period of inactivity.

Ground Plates Ground plates hold no facets, but are the starting point of every stack. They provide stability and help to distinguish tangibles that form stacks and those that are merely placed on the surface, outside of a query.

Stackables also require a computer—to analyze and issue the search queries built with the facet tokens—and an output display that shows the results of one ore multiple parallel queries. In contrast to previous work [3, 6], we thus clearly separate input and output space.

Stackables: Interaction

Five operations can be performed on Stackables using the two wheels, the button, and token orientation.

Facet Selection and Deletion When no facet has yet been chosen, the display shows the available facets of the loaded dataset. These facets can be navigated with the wheels and a selection is made using the button (Fig. 3, B). Once a selection is made, the display shows the available facet values. To reset a token, the button must be held for three seconds. An alternative design involves shaking the token to reset it—however, this interaction is only possible when the token is not part of a stack.

Single-Value Selection We designed the interaction to allow for the selection of facet values in arbitrarily large facet ranges. The top wheel performs single steps through facet values while the bottom wheel uses larger discrete steps within the whole range. Single facet values can also be saved by pressing the button to allow for logical OR connection of facet values (R2) akin to the Alphaslider [1].

Range Selection Range selection is activated by twisting the top and bottom wheel apart at the same time. The screen of the token always shows the currently selected beginning and end values of a range, as well as some values in-between. During range selection the bottom wheel steps through values one-by-one so that the beginning and end values of a desired range can be exactly specified. Range selection is de-activated once the top and bottom wheel again point to the same facet value. Range selections, like single-value selections, can be saved by pressing the button. Through the save function both single- and range-value selection can be combined (R2).

Query Construction Multiple facet tokens can be combined with a logical AND through vertical stacking (Fig. 4), similar to a vertical Filter/Flow [9] principle. The display shows the availability of facet values given a selection further below in the stack. Selected values can be changed for tokens placed within and outside of a stack. The display grays out unavailable values (see Fig. 4). This type of query construction relates to similar GUIs in IR [2, 9] and information visualization [7] which use virtual blocks to manipulate boolean and faceted queries. Anick et al.'s boolean query blocks can be OR-/AND-connected through 2D placement of terms in rows and columns [2]. FacetLens [7], similar to our system, offers dedicated support for selecting individual facet values through a virtual containment interface of value bubbles.

Negation Negation of a selection can be achieved through a combination of "saves" of single and range-facet values or by simply placing a Stackable token upside-down in a stack. The display rotates to show the values in correct orientation. All available facet values other than the currently selected ones now take part in the query.

Together, single-value selection, range selection, stacking, and negation support R2 through the basic principles of faceted information seeking and simple boolean queries.

Result Representation The output of one or multiple queries is shown on a display or projection. The result view shows a representation of the current stacks formed

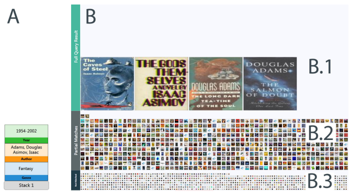

Figure 5: Result representation of a query with three Stackables in a single stack (A). B.1 shows the cover of all books matching all selected facets values in the stack, B.2 shows partial matches, and B.3 all books matching no selected facet value.

Figure 6: Assembly of the components of Stackables in a wooden box.

by the participating Stackables (Fig. 5, A) and a representation of the results of the queries (Fig. 5, B). The result representation shows three categories of results (B.1-B.3): perfect matches which satisfy all participating queries (all formed stacks), result showing partial matches (items matched by only some stacks or parts of a stack), and all unmatched items. While participating users interact with the tangibles and reorder the stacks, the visualization updates immediately to show new results and near matches. This behavior allows people to actively explore a dataset and adjust queries on the fly.

Realization and Evaluation

During the development of Stackables, we built a series of five prototypes of different hardware, materials, and stacking solutions. The latest Stackable tokens consist of two main components: a mobile phone with dedicated software to display facets and their values and a small Arduino FIO micro-controller of the open source Arduino project (cf. Fig. 6). Our preferred stacking solution uses reed switches or NFC tags. It, thus, differs from previous solutions which required the presence of a digital tabletop display [3]. Interactions with the latest prototype were evaluated with 12 participants. The results validated the interaction concept, showed that our requirements were well translated into design, but also exposed areas for improvement we are currently incorporating.

Conclusion

Making information seeking both more efficient and simple is an important research endeavor. We developed Stackables as a new tangible solution for faceted browsing and search and make three main contributions: we a) explore the feasibility of vertical stacking for query construction, b) provide a flexible interaction concept for large datasets with many facets and facet values, and c) constructed Stackables to be usable in face-to-face meetings and for individual use. We are currently working on extending our set of Stackable tokens for a usage scenario involving small groups of 2–4 participants.

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